4 ENVIRONMENTAL CONSEQUENCES

The proposed action is to resume L-Reactor operation as soon as practicable to produce needed defense material (i.e., plutonium). The Department of Energy's (DOE) preferred alternative is to operate L-Reactor after the construction of a 1000-acre lake to cool the reactor's thermal discharge to meet water-quality standards of the State of South Carolina. DOE has changed the preferred alternative it presented in the Draft Environmental Impact Statement (EIS), which was to operate L-Reactor with direct discharge to Steel Creek with subsequent mitigation, as a result of public comment and discussions with regulatory authorities.

The Department of Energy has identified the 1000-acre lake, with modifications of the reactor power levels, as the preferred thermal mitigation alternative following discussions with the South Carolina Department of Health and Environmental Control (SCDHEC) and the U.S. Army Corps of Engineers (COE). This alternative would comply with the State's water-quality standards by assuring the existence of a balanced biological community (balanced indigenous population TC
and balanced biological community are used interchangeably in this EIS) and it could be constructed by the Corps of Engineers in about 6 months. The 1000-acre lake is one of 33 cooling-water alternatives evaluated in the Final EIS; its expected environmental effects were bracketed by the cooling-water alternatives evaluated in the Draft EIS (i.e., a once-through 500-acre lake, a 1300-acre recirculating lake, and modified reactor power operation). The 1000-acre lake is the largest lake possible considering the terrain of the Steel Creek valley that can be constructed by the Corps of Engineers within a single construction season and the smallest lake allowing maximum operational flexibility.

This chapter discusses the potential environmental effects of L-Reactor for normal operation under reference-case assumptions, for postulated accidents, transportation, mitigation alternatives (safety, cooling water, disassembly-basin purge-water disposal, and 186-Basin sediment disposal), decontamination and decommissioning, and safeguards and security. The expected environmental effects of the preferred alternatives are discussed separately in Section 4.5.

4.1 NORMAL L-REACTOR OPERATION

This section characterizes the expected nonradiological and radiological effects due to normal operation of L-Reactor. Nonradiological effects include those that might result from an increased workforce, the withdrawal and discharge of cooling water, the discharge of liquid and atmospheric chemical effluents, and the disposal of solid nonradioactive wastes. This section does not consider cooling-water mitigation measures, which are described in Section
4.4.2; however, it does discuss the effects of direct discharge to Steel Creek, TC
which is referred to as the reference case, to which other alternative cooling-water mitigation measures can be compared. Radiological effects include those that might result from airborne and liquid radionuclide releases, the disposal of radioactive wastes, and the resuspension and transport of radiocesium and cobalt-60 in Steel Creek.

4.1.1 Nonradiological impacts

4.1.1.1 Land use and socioeconomics

Land use

The proposed resumption of L-Reactor operation under the reference case would not alter existing land use on the Savannah River Plant (SRP) site, nor would it require the acquisition or the use of land off the SRP site; therefore, no direct land-use impacts are expected.

Four historic sites and one prehistoric site in the Steel Creek terrace and floodplain system have been determined to be eligible for inclusion in the National Register of Historic Places. A mitigation plan has been developed to ensure the preservation of these resources, and the plan has been approved by the South Carolina State Historic Preservation Officer (Du Pont, 1983b). Stage I of this mitigation plan involves monitoring to ensure that the sites would not be directly impacted by L-Reactor operation. This monitoring phase has been ongoing; during cold-flow testing conducted in 1983, erosion of three sites (38BR112, 38BR269, and 38BR286) was observed. Stage II (mitigation) has been implemented and protection of the sites by riprap as specified in the mitigation plan is being accomplished under the guidance of the University of South Carolina Institute of Archeology and Anthropology.

TC

Socioeconomics

Operational employment for L-Reactor, which began in 1981, peaked at about 400 employees in mid-1983 and is expected to decrease to 350 by mid-1984, or about 4 percent of the current workforce at the Savannah River Plant (Du Pont, 1982b). Essentially all the operating workforce for L-Reactor has been hired and resides in the SRP area; therefore, no additional impacts are expected to local communities and services due to in-migrating workers.

L-Reactor operation is expected to have annual total local expenditures on materials and services of approximately $3 million and a total payroll and overhead expenditure of about $21 million. These expenditures are expected to result in the creation of about 50 regional job opportunities. In addition, these are expected expenditures to produce an additional direct and indirect income of another $3 million. The total economic benefit to the SRP region during L-Reactor operation would amount to at least 400 direct and indirect job opportunities, about $25 million in direct and indirect annual income and payroll, and $3 million in direct annual expenditures on materials and services.

These contributions to the local economy would help pay for public services directly through income, property, and license taxes and user fees and indirectly through sales taxes on goods and services. The benefits provided by the project would help offset the small increase in demands for local services that it generates.

4.1.1.2 Surface-water usage

Under the reference case (direct discharge to Steel Creek), the once-through cooling-water system, similar to that used during the previous L-Reactor operation, would withdraw about 11 cubic meters per second of water from the Savannah River. This would be less than 4 percent of the average flow and 7 percent of the 7-day, 10-year low flow of 295 and 159 cubic meters per second, respectively. Because little L-Reactor cooling water would be consumed, essentially all water withdrawn from the river would be returned to the river after passing through the L-Reactor heat exchanger and the Steel Creek system. The estimated consumptive water use by L-Reactor is 0.85 cubic meter per second (Neill and Babcock, 1971). EL-2

Withdrawal of cooling water for L-Reactor operation would affect the aquatic ecology of the Savannah River by (1) the entrainment in the cooling water of aquatic organisms (predominantly fish eggs and larvae) smaller than the screen mesh in the intake system, and (2) the impingement of aquatic organisms (primarily fish) on the intake screens.

Entrainment

An expanded Savannah River aquatic ecology program was initiated in March 1982 to evaluate the impact of the Savannah River Plant, particularly L-Reactor restart, on the Savannah River fisheries (Appendix C). Data from previous studies conducted in 1977 (McFarlane et al., 1978) were also used in this impact analysis (see Appendix C). In general, the projected levels of entrainment and impingement developed from the 1982 investigations are similar to those based on the 1977 results. However, some differences do exist. A discussion of these impacts is given in the following sections.

The analysis of the data obtained in 1983, during the second year of the expanded aquatic ecology program, is still preliminary. However, the 1983 results have been used in certain parts of the impact assessments below. AY-6

Estimates of the numbers of fish larvae that could be entrained by the cooling water of the L-Reactor and the other SRP installations were obtained in the following manner. The average density of larvae found in the replicate samples taken from the intake canals was multiplied by the total volume of water pumped into the intakes during each 24-hour sampling period. This calculation estimated the total number of larvae that was entrained during each day of sampling. These individual totals were extrapolated for the days when samples were not taken to estimate entrainment numbers for the entire spawning period.

Estimates of the numbers of fish eggs that could be entrained were made in a similar manner. However, densities of eggs found in the samples taken from the river adjacent to the intake canals were used as a basis for the calculations instead of the densities obtained in the canals themselves because samples from the intake canals are believed to underestimate the egg densities; the water velocities in the canals are not sufficient to support drifting semibuoyant eggs. Entrainment in the 3G and 5G intake canals was calculated using the density of eggs immediately upstream from 3G. The egg densities for 1G were calculated as a volume-weighted average of the egg densities in the river upstream from 1G and in Upper Three Runs Creek, because a large portion of the discharge of Upper Three Runs Creek enters the 1G intake canal.

According to the results of the 1982 studies and predicted L-Reactor withdrawal rates, it is estimated that approximately 7.7 x 10^6 fish eggs and 7.6 x 10^6 fish larvae would be entrained by the L-Reactor cooling water each year during the spawning season. The corresponding projections based on the 1983 data are 3.8 x 10^6 eggs and 11.9 x 10^6 larvae (see Table 4-1). These totals represent approximately 6 percent of the fish eggs and larvae contained in the Savannah River water passing the intake canal during the 1982 spawning season and 3 percent during the 1983 spawning season.

AY-6

Table 4-1 compares the entrainment projections derived from the 1977, 1982, and 1983 ichthyoplankton surveys. In general, the loss estimates from all three studies are similar, although the 1982 estimates of egg entrainment and the 1983 estimates of larval entrainment are somewhat higher than those of the other years. (Appendix C contains data on the relative abundance and species composition of eggs and larvae collected.) This might be due either to differences in collection methods used during the two studies or to natural year-to-year variations in abundance. One of the objectives of the current Savannah River fisheries program is to attempt to determine the cause of these differences.

For the impact assessments made in this document, the worst-case situation is assumed and the highest projections of fish egg and larvae entrainment are used (i.e., egg data from 1982 and larval data from 1983). Accordingly, the restart of L-Reactor would result in the entrainment of 7.7 x 10^6 additional fish eggs and 11.9 x 10^6 additional fish larvae annually.

AY-6

Impingement

TC

Impingement studies were first performed at SRP in 1977 (McFarlane et al., 1978) and were resumed in March 1982 as part of the expanded Savannah River aquatic ecology program. The results of these investigations indicate that the impingement rate is influenced to some degree by several factors, including the number of pumps in operation, the volume of water pumped, the river water level, the water temperature, and the density and species of fish in the intake canal; only some of these factors will be affected when the L-Reactor begins operation. Accordingly, the estimates of incremental increases in impingement due to L-Reactor should be used for comparative purposes only.

A total of 684 fish representing 35 species was collected during 52 impingement samplings from March 1982 through February 1983 at the 1G, 3G, and 5G pumphouses. The number of fish impinged varied from 0 to 98 in a 24-hour period, with an average of 13.2 fish per sample. This is higher than the impingement estimates from 1977 of 7.3 fish per sample (McFarlane et al., 1978). According to the 1982 data, the restart of L-Reactor would result in an additional 6 fish per day impinged during normal river flow conditions, or a cumulative total of about 19 fish per day for all SRP operations.

AY-6

The data from the 1983 portion of the ongoing impingement studies indicate that more fish were impinged that year than previously. The information for the 12-month period ending August 1983 (the last date for which data are available) was analyzed to evaluate the latest data.

A total of 3604 fish representing 48 species were impinged on the SRP intake screens during ninety-eight 24-hour samples taken between September 1982 and August 1983. The impingement ranged from 0 to 540 fish per day. The weight of fish impinged ranged from 0.1 gram to 22.9 kilograms per day. The total weight of the fish impinged during the entire period was 91.3 kilograms. During this 12-month period, an average of about 37 fish per day were collected in the impingement samples. At this rate, a total of 13,505 fish would be impinged annually.

The majority of the fish were in the family Centrarchidae (71 percent) or the family Clupeidae (15 percent). The most common fish, bluespotted sunfish,
AY-6 represented 35 percent (1259) of the total fish collected.

The total number of fish impinged showed a sharp increase in mid-March 1983 and remained high through early May 1983. This high impingement coincided with considerably higher river water levels than those that occurred during the remainder of the sampling year. During the period of high impingement, most species had only slight increases in numbers impinged; however, a sharp increase was observed in the numbers of bluespotted sunfish and pirate perch caught on the screens. Both species generally inhabit slower moving areas of the river, but they could have been driven out by high water.

Figure 4-1 shows the average number of fish impinged at the three intake canals and the Savannah River water levels from March 1982 through August 1983.

It is estimated that, under average conditions (based on 1983 data), an additional 16 fish would be impinged each day due to the restart of L-Reactor,
AY-6 owing to increased withdrawal. An estimated 5840 fish per year could be impinged due to L-Reactor operation.

Surveys of the recreational fishery in the fresh-water portions of the Savannah River indicate that the species caught in greatest numbers by anglers are bream (i.e., bluegill, warmouth, and sunfish), crappie, and catfish (i.e., catfish and bullheads). These species make up about 37 percent of the total number of fish collected during the impingement studies. Using these data, estimates can be made of the numbers of these recreationally important fish that would be lost due to impingement. Table 4-2 summarizes these estimates.

The largemouth bass is another important sportfish; it is the second most sought-after fresh-water species in the Savannah River. However, because it is not often caught, it does not rank highly in annual catch statistics. This species is impinged rarely at SRP, comprising about 0.3 percent of the total fish collected (i.e., 2 individuals from a total of 684). The projection of annual losses under present operating conditions is 14 fish. An additional 6 largemouth bass would be lost annually as a result of L-Reactor operations.

4.1.1.3 Ground-water usage

During the renovation of L-Reactor, two new wells were drilled. In 1981 and 1982, they produced about 0.28 cubic meter per minute from the Tuscaloosa Formation. They produced about 0.94 cubic meter per minute in 1983. This withdrawal rate is not expected to increase when L-Reactor operation is resumed (Du Pont, 1981b).

Table 4-2. Estimated numbers of fish that would be lost annually due to impingement under average river flow conditions (based on data from September 1982-August 1983)

Species	Percentage of total number impinged	Estimated loss under present operating conditions	Loss due to L-Reactor operation (estimated)	Total loss with L-Reactor operational (estimated)
AY-6 Bream	20	2,633	1114	3,747
Crappie	3	436	184	620
Catfish	3	335	142	477
Largemouth bass	0	30	13	43
Other species	74	9,989	4226	14,215
All species	100	13,423	5679	19,102

When L-Reactor is operational, withdrawal of ground water from the Tuscaloosa Aquifer (excluding incremental pumping by its support facilities), is estimated to be 20.5 cubic meters per minute at the Savannah River Plant and about 56.5 cubic meters per minute from all users within about 32 kilometers of Savannah River Plant (Sections 3.4.2.5 and 5.1.1.4). Siple (1967) concluded that the Tuscaloosa aquifer could supply 37.8 cubic meters per minute at SRP with no adverse effects on the pumping capabilities in existing 1960 wells. Total SRP pumping from the Tuscaloosa in 1960 was about 18.9 cubic meters per minute.

Drawdown calculations for the Tuscaloosa Aquifer suggest that water levels at the Plant boundary opposite A- and M-Areas would rise in relation to the levels measured in 1982 (Georgia Power Company, 1982; Du Pont, 1983h) if the SRP
AW-1 pumping rate decreases from 23.8 (1982) to 20.5 cubic meters per minute. These projected increases would be about 0.5 meter at Jackson and 0.4 meter at Talatha. Long-term cyclic water-level fluctuations near SRP often exceed 2 meters (see Figure F-12).

Computer modeling (Marine and Routt, 1975) indicates that the best estimate of the ground-water flux in the aquifer is about 110 cubic meters per minute throughout the Savannah River Plant and adjacent areas (Figures F-25 and F-31 show the study area). The current ground-water flux through the Tuscaloosa in the Marine-Routt study area is conservatively estimated to be 51 cubic meters per minute, which is the study's lower-bound estimate (see Section F.4.2). This compares with a withdrawal rate from the study area of 32.0 cubic meters per minute (20.5 for SRP + 11.5 for neighboring offsite users). Incremental and cumulative ground-water withdrawals are described in Sections 5.1.1.4 and 5.2.3, respectively.

Pumping tests were conducted on both new L-Area wells. One well had a drawdown of 8.2 meters and the other a drawdown of 12.2 meters when tested for a short period of time at flow rates of 2.8 cubic meters per minute. From the average specific capacity of 0.27 cubic meter per minute per meter derived during the pumping tests, a short-time drawdown of 3.5 meters (including well entrance losses) at the center of the cone of depression is calculated for an L-Area well producing 0.94 cubic meter per minute.

The total drawdown 0.3 meter from the center of the cone of depression is 4.6 meters when the entrance losses are subtracted and the effects of pumping elsewhere on the Savannah River Plant are included. The upward head differential between the Tuscaloosa and Congaree Formations in L-Area is calculated to be about 3.7 meters (Figure 3-9). Thus, 0.3 meter from the center of the cone of depression, the head differential is about 0.9 meter downward. The upward head differential at the L-Area seepage basin, about 400 meters from the A-Area wells, is calculated to be 1.4 meters, principally in response to pumping in L-Area. Measurements of upward differentials over the last 10 years show a gradual decline of about 0.16 meter per year (Section 3.4.2.5). This rate of decline, if it continues, will further reduce the upward head differential beneath the L-Area seepage basin. However, because pumping rates at SRP are expected to remain less than the 1983 rate (see Table F-10) over the next 6 years (Sections 5.1.1.4 and 5.2.3), this trend is expected to be retarded. The hydrostratigraphic properties of the formations underlying the L-Area seepage basin [principally the green clay (see Section 4.1.2.2) and the pisolitic clay at the base of the McBean and Congaree Formations, and the thick upper clay layer of the Ellenton Formation (Table F-1)] will tend to protect the Tuscaloosa from contamination by the seepage of pollutants that enter the overlying shallow ground-water units. The upward head differential will provide additional protection.

As noted in Section 4.1.2.2, contaminants from the L-Reactor seepage basin that reach the water table are expected to follow a ground-water travel path to Steel Creek, where they will be discharged through seepline springs. Any contamination that might reach the Congaree or Tuscaloosa from L-Area would flow beneath the SRP to the Savannah River and would not affect offsite ground-water users; the following ground-water transient times have been estimated (Figures F-25 and F-26 for flow paths and Table F-1 for flow velocities): AW-1

- Congaree Formation -- 76 years
  [(12.2×10^3 meters)/(160 meters per year) = 76 years]

- Tuscaloosa Formation -- 250 years
  [(13.1×10^3 meters)/(52.2 meters per year) = 250 years]

Pumping from the Tuscaloosa in L-Area will have no effect on the heads in the Congaree and overlying formations because this aquifer has a very poor hydraulic connection with them. The withdrawal of ground water from the Tuscaloosa in L-Area is not expected to affect either the quality of the water or the offsite water levels in the aquifer.

In conclusion, the withdrawal of ground water for L-Reactor would be about 0.94 cubic meter per minute. The ground-water withdrawal from the Tuscaloosa is projected to decrease when L-Reactor operation resumes (excluding incremental pumping in support of L-Reactor) compared to 1982 pumping; water levels are expected to rise as a new equilibrium piezometric surface is established at SRP and neighboring areas. At Jackson and Talatha, projected water levels would

AW-1 increase by 0.5 and 0.4 meter, respectively, if sitewide pumping decreases to 20.5 cubic meters per minute. However, pumping at L-Area would draw down the water in the Tuscaloosa locally, and thereby reduce the upward head difference between the Tuscaloosa and Congaree to about 1.4 meters beneath the L-Reactor seepage basin. The withdrawal of ground water from the Tuscaloosa would not affect water levels in overlying aquifers because of the thick Ellenton clay unit and the basal Congaree Clay. Important clay layers, principally the green clay, beneath the L-Reactor seepage basin would tend to protect the Congaree and Tuscaloosa Aquifers; any contaminants that might reach these aquifers are expected to flow beneath the SRP to the Savannah River in an estimated 76 to 250 years, respectively, and would not affect offsite ground-water users.

4.1.1.4 Thermal discharge

TC The direct discharge of L-Reactor cooling water to Steel Creek, discussed here, is the reference case to which all mitigation measures (including the preferred alternative) are compared (see Section 4.4.2). The preferred alternative is discussed in Section 4.5 and Appendix L. Section 7.5 discusses the NPDES permit for L-Reactor.

The L-Reactor cooling system would discharge thermal effluent directly into Steel Creek, one of five major creeks that drain the Savannah River Plant and flow into the Savannah River. The temperature of the effluent at the outfall canal would reach 73°C during extreme meteorological conditions. The effluent TC would flow at a rate of about 11 cubic meters per second (natural flow in the creek at Road B is about 0.17 cubic meter per second; see Section 3.4.1.2). Modeling (Du Pont, 1982b) of L-Reactor thermal effluents at two power levels (Figure 4-2) indicated that the thermal discharge would enter the swamp at temperatures between 40°C (spring) and 45°C (summer). Table 4-3 presents temperatures that could occur at selected points along Steel Creek under the most severe 5-day meteorological conditions (as determined from conditions between 1976 and 1980). If L-Reactor is operated under these severe conditions, the water temperature of Steel Creek above its delta would exceed 40°C; the temperature of the effluent when it reaches the Savannah River would be about 33°C TC (Table 4-3).

The thermal impact to wetlands would be expected to be similar to conditions that occurred when L-Reactor operated previously. During the past 15 TC years, through the process of natural succession, these wetlands have become reestablished. They are, however, structurally different from the closed canopy of mature cypress and tupelo gum that existed before SRP began operations (Sharitz, Irwin, and Christy, 1974). Elevated temperatures and water levels would eliminate between 420 and 580 acres of wetland vegetation within the Steel Creek corridor. Portions of these areas would revert to mudflats. Sediments would be transported downstream and deposited on the delta, contributing to its physical buildup and impacting vegetation.

With the reference case and other once-through alternatives, emergent wetland flora and submergent hydrophytes, which have revegetated the Steel Creek delta since 1968, would be eliminated and their substrates would also revert to mudflats after resumption of operations. Some herbaceous flora have also become established on exposed floodplain sediments and elevated stumps and logs of

Table 4-3. Predicted seasonal water temperatures of Steel Creek as a result of L-Reactor operation (maximum load) and direct discharge

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
L-Reactor outfall	73[c]	71	69	66
Road A	54	53	50	46
Road A-17	47	46	42	37
Swamp at delta	46	45	41	36
Mid-swamp	37	35	31	25
Mouth of creek at Savannah River	34	33	28	21

[a]Based on the worst 5-day meteorological conditions (July 11-15, 1980) and the estimated operating power of the reactor. Five-day worst-case meteorological conditions provide the basis for a conservatively high estimate of discharge and downstream temperatures that are likely to result from the implementation of a thermal mitigation alternative. The selection of 5-day worst-case meteorology is also based on a typical cycle of consecutive meteorological conditions; it is considered representative of extreme temperatures for which the maintenance of a balanced biological community can be measured under Section 316(a) of the Federal Water Pollution Control Act of 1972.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]The secondary cooling-water discharge temperature during extreme summer meteorological conditions has been reduced to 73°C. This reduced temperature reflects reduced reactor operating power to compensate for increased temperatures in the cooling-water supply drawn from the Savannah River during the warmest summer months.

TC

fallen trees. Most of the scrub-shrub and willow-dominated communities would be eliminated. Between 310 and 420 acres of the delta and swamp vegetation would be lost. Riverine vegetation near the mouth of Steel Creek consists primarily of bottomland hardwood forests; emergent and submergent macrophytes are sparse or absent. Temperatures as high as 11°C above ambient for short periods of time probably would not impact these flora. Temperatures of 11°C or higher above ambient are expected to occur about 10 times a year; each occurrence is expected to last about 2.5 days.

EN-16

Flooding and siltation (from erosion of the stream bed and banks) associated with the thermal discharge at 11 cubic meters per second are expected to modify aquatic habitat in the Steel Creek floodplain and delta. The delta is expected to expand into the swamp at a maximum rate of about 3 acres per year. This growth rate was calculated using historic data (Ruby, Rinehart, and Reel, 1981) for the period when L-Reactor discharged 186-Basin and cooling-water effluents to Steel Creek. Wetland habitat is expected to be eliminated or modified at a rate of about 7 to 10 acres per year due to thermal discharge and its associated flooding, siltation (Smith et al., 1981), and fluctuating water

AW-3

levels. If the L-Reactor resumed operation with direct discharge, about 420 acres of the wetlands in the Steel Creek corridor and about 310 acres in the swamp area, or about 730 acres total, would be initially affected (reference case). The 1000 acres of eliminated habitat represent a conservative estimate of the wetlands that would be affected over a number of years of reactor operation. |TC

Wildlife

Except for backwater pools or other cool-water refuges, the high water temperatures from the outfall to the delta (resulting from direct discharge, the reference case) would make the section of Steel Creek below L-Reactor uninhabitable for amphibian eggs and larvae. Adult life forms might survive along the stream margins or relocate to adjacent habits.

Reptiles are more dependent on aquatic habitat for food (i.e., insects, fish, amphibians) and shelter than for reproduction. The elevated water temperature and the elimination of prey organisms would eliminate the habitats of semiaquatic snakes and turtles upstream from the delta and would cause a marked decrease in species richness. Portions of the delta might provide marginal habitat for water snakes and turtles following L-Reactor restart.

The endangered American alligator inhabits all parts of Steel Creek from the L-Reactor outfall to the cypress-tupelo forest adjacent to the Steel Creek delta; it also uses areas lateral to Steel Creek, including Carolina bays, backwater lagoons, and beaver ponds. The number of alligators inhabiting the Steel Creek area ranges during the year between 23 and 35 individuals. Telemetry studies showed that males had larger home ranges than juveniles and females; males sometimes moved from the delta into the Savannah River swamp. The release of cooling water from L-Reactor would eliminate alligator habitat in Steel Creek from the reactor outfall to the Savannah River, except for backwater pools or other cool-water refuges, by increasing the water temperature above physiologically tolerable limits, eliminating principal food sources, and possibly inundating nests and shallow-water wintering habitats (Smith et al., 1981, 1982). Red sore, a bacterium-caused disease that affects fish and reptiles, could become more prevalent with thermal loading and could affect the American alligator. Conditions conducive to the reproduction of this bacterium, however, are very specific (i.e., water temperature, pH, etc.).

L-Reactor startup would take several days. Adult alligators should be able to avoid heated areas and emigrate to suitable nearby habitats. During winter, alligators might seek the warmer effluent waters until temperatures again rise above acceptable limits in late spring and summer. Juveniles also would be expected to avoid thermal effluents, but these smaller alligators would have more difficulty relocating to suitable habitats and would be exposed to greater predation. A startup in late spring and summer could destroy both nests and eggs. Winter startup could be fatal to torpid individuals that overwinter in shallow-water areas along the creek and in the delta. The DOE has initiated the consultation process with the U.S. Fish and Wildlife Service to determine the needed mitigation measures in the event of a winter or spring startup.

The Savannah River swamp and Steel Creek delta provide an important regional sanctuary and refuge for waterfowl. Over 400 wood ducks and nearly 1200 mallards have been observed roosting and feeding in the Steel Creek delta.

Seven other species of waterfowl also use this area. The Steel Creek delta also provides important foraging habitat for the wood stork, a large wading bird that is listed as an endangered species (USDOI, 1984). A total of 102 birds was observed feeding in the Steel Creek delta in 1983. No wood stork nests occur on the SRP site. (DOE has initiated a consultation process with the U.S. Fish and Wildlife Service on the wood stork.) Thermal discharge would eliminate feeding and roosting habitat due to vegetative mortality and would adversely affect food sources such as fish because water temperatures would preclude their presence.

Semiaquatic mammals that would be affected by the thermal effluent include the beaver, river otter, mink, and muskrat. Adults should not experience mortality due to increased flow and temperature, but flooding during the breeding season could adversely affect the young. Except for the muskrat, these species are common throughout the Savannah River Plant.

Aquatic biota

The direct discharge of cooling-water effluent to Steel Creek (reference case) would eliminate most of the biota of the main channel from the L-Reactor outfall downstream to the delta. Populations of thermotolerant and thermophilic algae, such as blue-greens, would be expected to increase (Gibbons and Sharitz, 1974). These organisms thrive in areas where species more sensitive to elevated temperatures cannot compete. According to information on the SRP thermal streams (Four Mile Creek and Pen Branch), few higher organisms are likely to survive in the main-stream channel of Steel Creek. As the effluent moves away from the L-Reactor outfall, the temperature would decline and more organisms would occur, beginning with the most thermally tolerant (Du Pont, 1982b).

During thermal discharge, Steel Creek would not be suitable for fish of recreational or commercial importance; fish presently in Steel Creek would move to avoid heated effluents. In addition, the warmer waters of Steel Creek might prevent access to the floodplain swamp by fish from the river. Temperature tolerance data indicate that most, if not all, spawning activity could be eliminated by the thermal effluent; however, other similar spawning habitat is available in thermally unaffected areas on the Savannah River Plant and along the Savannah River. The most common fish remaining in the Steel Creek area probably would be the mosquitofish, although a few centrarchids might occur in backwater areas and tributary streams such as Meyers Branch (Cherry et al., 1976; Falke and Smith, 1974; Ferens and Murphy, 1974; McFarlane, 1976; McFarlane et al., 1978).

Although 2280 acres of the wetlands along Steel Creek above L-Area and along Meyers Branch above its confluence with Steel Creek would not receive direct thermal discharges, access to these areas by fish from the Savannah River will be restricted. The entrance to Boggy Gut Creek, an offsite tributary immediately downriver of Steel Creek, could be blocked by the thermal plume at times and fish access would be limited. Wetland areas of Boggy Gut total about 230 acres.

Thermal discharge to the Savannah River

Existing thermal discharges from the Savannah River Plant to the Savannah River include those from K-Reactor, which discharges to Steel Creek via Pen Branch, and C-Reactor and the D-Area powerhouse, which discharge to the Savannah

River via Four Mile Creek and Beaver Dam Creek, respectively. With the reference case, the resumption of L-Reactor operations would increase the thermal discharge to Steel Creek below its confluence with Pen Branch and increase the size of the thermal plume in the Savannah River.

Thermal plume. Since 1968 (K-Reactor operating and L-Reactor on standby), the discharge to the Savannah River from Steel Creek has been about 15.6 cubic meters per second at temperatures typically less than 5.6°C above ambient river temperature (Du Pont, 1982b). Judging from previous operating experience, the discharge with both K- and L-Reactors operating should increase to about 27.4 cubic meters per second; during the warmer months, the creek-to-river delta-T should average about 7.2°C.

The thermal plume from Steel Creek would remain on the South Carolina side of the Savannah River until it becomes completely mixed with the river water, typically about 1.5 river miles (2.4 kilometers) downstream from the mouth of the Steel Creek (Du Pont, 1983b). Thus, a zone of passage for anadromous fish would exist in the river.

Computer simulations were used to predict the temperature in the Steel Creek thermal plume and at the point of entry into the Savannah River to the point of complete mixing of the plume with river water, about 1.5 river miles downstream from the mouth of the Steel Creek (Du Pont, 1983b). Figure 4-3 shows the results of this modeling for a river flow of 175.6 cubic meters per second at the mouth of Steel Creek that, with two reactors operating, corresponds to a flow of 178.4 cubic meters per second at Augusta (River Mile 187.4). A flow of at least 178.4 cubic meters per second is maintained 80 percent of the time at Augusta by the Army Corps of Engineers (see Section 3.4.1). Under the conditions shown in Figure 4-3, a creek-to-river delta-T greater than 9°C would be required to exceed a 2.8°C temperature difference across a mixing zone boundary in the river defined by 25 percent of the cross-sectional area of the river (see the upper, solid curve). The lower, dashed curve represents the temperature difference along a 33-percent surface-area mixing zone boundary.

Figure 4-4 is a compilation of the modeling results discussed above. The upper (solid) curve represents the calculated creek-to-river delta-T for corresponding river flows and only L-Reactor discharging to Steel Creek. Similarly, the lower (dashed) curve represents the case when the thermal effluent from both K- and L-Reactors is discharged through the mouth of Steel Creek.

The temperature increase of the Savannah River would depend on several factors: the time of the year, flow rates of the river, and SRP operating conditions. Table 4-4 lists the projected increases in water temperature from L-Reactor during August as a function of flow with three reactors discharging to the river.

Computer simulations also show that the mouth of Boggy Gut Branch would be affected by the L-Reactor thermal plume. These effects for the spawning months of February through June are shown in Figure 4-5; the computed temperature at the mouth of Boggy Gut Branch is plotted for the case of both K- and L-Reactors discharging through the mouth of Steel Creek and a river flow of 320 cubic meters per second. This river flow, which is 82 percent of the average flow during the 5-month spawning season (Figure 3-6), was chosen to reflect lower

Table 4-4. Projected L-Reactor contribution to the mixed river temperature increase during August[a]

Savannah River flow at Ellenton Landing (m^3/sec)	L-Reactor contribution to river temperature increase (°C)	Description of flow at Ellenton Landing
159.0	0.70	7-day, 10-year low flow
179.4	0.67	Mean for annual 7-day low flows, 1964-1983
295.0	0.45	Long-term average flow

[a]Adapted from Du Pont (1982b).

flows that might occur as the result of the filling of Russell Dam (Section 3.4.1) and lower flows during periods of drought. Two temperature curves are plotted for the mouth of Boggy Gut Branch, one for a Steel Creek-to-river delta-T of 7.2°C (average) and another for a delta-T of 11.1°C (24 events per year with a 2.5-day duration on the average). Figure 4-5 also shows the monthly average maximum river temperature measured daily at Ellenton Landing.

Ecological impacts. Direct discharge would produce a thermal impact on the Savannah River only near the mouth of Steel Creek. Downriver from the confluence of Steel Creek with the river, no adverse impacts to reptiles, birds, or mammals that inhabit the river's riparian habitats are expected.

The temperatures near the mouth of Steel Creek could be high enough to exclude the creek and its floodplain as potential spawning areas for riverine and anadromous fish such as the blueback herring during the spawning season. However, temperature measurements in the river (Du Pont, 1982b) and thermal modeling indicate that the thermal plume would remain close enough to the South Carolina shore to permit a zone of passage for migrating fish such as American shad, blueback herring, striped bass, and Atlantic and shortnose sturgeon (Du Pont, 1982b).

Studies were conducted by the Academy of Natural Sciences of Philadelphia (ANSP, 1953, 1957, 1961, 1967, 1970, 1977) to monitor the effects of SRP operations on the general health of the Savannah River. ANSP studies (Matthews, 1982) indicate that no major changes in the presence of species have occurred from past Savannah River operations at their stations or are expected to occur from the addition of heat and cooling water from L-Reactor.

4.1.1.5 Wastewater discharges

Liquid effluent discharges to Steel Creek

Liquid effluent from L-Area would have chemical compositions that are similar to those from other SRP reactor areas. The L-Area effluent streams and their approximate annual flow rates are listed in Table 4-5.

Table 4-5. Sources of effluent streams to Steel Creek from L-Area[a]

Effluent stream sources	Approximate annual flow rate (m^3)
Cooling water, process water, cooling reservoir, sanitary wastewater	3.4×10^8
Heating/cooling, offices	1.4×10^4
Water treatment plant	2.6×10^5
Cooling water for engine building	1.6×10^6

[a]Adapted from Du Pont (1982b).

With the reference case, some of the chemicals discharged through these outfalls to Steel Creek would originate from the Savannah River water pumped through the reactor secondary cooling system. Table 4-6 lists estimated L-Area liquid effluent chemical loads and compares them with the corresponding water quality or drinking-water standard and with concentrations measured in Steel Creek and in the Savannah River above and below the Savannah River Plant. Available measurements from the Savannah River (Table 4-6; Marter, 1970; Matthews, 1982) indicate little variation in measured quantities between upstream and downstream locations from present SRP operations; L-Reactor operation would not be expected to alter this situation significantly. Because of the high cooling-water flow rates to Steel Creek, most chemical contaminants would be expected to be transported through the swamp into the Savannah River, although flocculated suspended sediments would be expected to settle and accumulate in the swamp. No significant impact on swamp-water quality would be expected.

Sanitary discharges

Sanitary wastewater would be chlorinated at a packaged treatment plant and discharged through the L-Reactor area wastewater sewer to Steel Creek. The sanitary wastewater-treatment plant is designed for a maximum flow of 132 cubic meters per day. The treatment-plant size was selected to be adequate for the expected operating work force. The discharge would meet NPDES permit (Du Pont, 1981a) requirements and would have no major impact on Steel Creek (Du Pont, 1982b). Sewage sludge would be transported to an existing basin near the Central Shops. Samples of sludge from similar treatment facilities indicate that it is not hazardous (Du Pont, 1982b).

Cooling-water reservoir (186-Basin)

The 95-million-liter cooling-water processing basin (186-Basin) is cleaned annually during periods of reactor shutdown to remove accumulated solids. About 110 metric tons of the 5530 metric tons of suspended solids that would enter the 186-Basin annually are expected to be deposited in the basin. This sediment would be flushed to Steel Creek over a period of several days. During flushing, the suspended solids concentrations in the effluent would be about 60 to 160 parts per million. This operation, which requires a variance from NPDES permit limits, is a continuation of current practice. It has been performed many times at the other reactors with no evidence of detrimental impact. Most of the suspended solids released from the 186-Basin would settle in the streambed before reaching the swamp (Kiser, 1977; Geisy and Briese, 1978; Du Pont, 1981a; Ruby et al., 1981). When L-Reactor discharges resume (about 11 cubic meters per second), the resuspension of some of this settled sediment could contribute a small amount of material to the delta, which is expected to grow at a rate of about 3 acres per year with direct discharge (reference case).

4.1.1.6 Atmospheric releases

Nonradiological pollutants emitted into the atmosphere as a direct result of the operation of L-Reactor would come primarily from the K-Area coal-fired steam plant and the diesel generators at the L-Area.

The steam demands for L-Reactor would require an additional 6400 metric tons of coal to be burned annually at the K-Area steam plant. Emissions of particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and volatile organic compounds from the steam plant would increase 15 percent, as illustrated in Table 4-7. This facility was constructed before 1975. No modifications are required; therefore, existing permits allow the production of additional power. TC

Fourteen emergency diesel generators are located in L-Area; six would operate continuously. The estimated annual diesel fuel consumption rate is 940 cubic meters for all generators. The emissions from these generators are listed in Table 4-7.

The operation of the L-Reactor would not violate any ambient air quality standard.

4.1.1.7 Solid wastes

Solid nonradioactive wastes generated by the resumption of L-Reactor operation would consist of trash and sanitary waste sludge. Trash would be generated at a rate comparable to those experienced by other SRP reactors; it would be disposed of in the SRP sanitary landfill. This landfill will be expanded from about 0.04 to 0.13 square kilometer. This expansion, which will occur in any event, ensures an adequate capacity for SRP operation, including L-Reactor, for many years (Du Pont, 1982b). Ten wells monitor the effluent from the landfill to the ground water of the McBean Formation. Quarterly analyses of water from these wells have shown little impact on the McBean ground water.

Periodically, treated sludge would be pumped from the sanitary waste treatment plant sludge holding tank to a mobile tank and transported to the sludge pit near the Central Shops area. Approximately 48,000 liters (50 percent water) of the sludge from L-Area would be disposed of in the sludge pit annually. No impact is expected on the operation of the sludge pit.

4.1.1.8 Noise

During the normal operation of L-Reactor, external noise levels would primarily be those associated with the movement of motor vehicles; they would be well within acceptable levels in the area. At the nearest offsite residence, about 10 kilometers away, noise from normal operations would not be detectable. Inside buildings, operators exposed to noise from machinery and other operating equipment would wear protective equipment in accordance with SRP standards and regulations of the U.S. Occupational Safety and Health Administration. TC

4.1.2 Radiological impacts of L-Reactor operation

The operation of L-Reactor would have radiological impacts similar to those of the currently operating SRP reactors. The net effect would be about a one-third increase in the release of radioactive materials to the environment, in the total occupational dose of SRP workers, and in the amount of radioactive waste to be disposed of in the high-level waste tanks and in the low-level waste burial ground. This section characterizes these radiological impacts due to the normal operation of L-Reactor only under the reference case (direct discharge of cooling water to Steel Creek). Radiological impacts due to SRP facilities that would support L-Reactor are addressed in Section 5.1.2. Appendix B describes dose calculation models and basic assumptions.

Figure 4-6 shows potential pathways for radiation exposures to man from radionuclides released from a nuclear facility. External doses result from exposure to airborne effluents, from swimming and other recreational activities, and from exposure to ground deposition of radionuclides. There are no known users of Savannah River water for irrigation downstream from SRP (Section 3.4.1.3); contaminants that might reach the ground water beneath SRP will not reach offsite sources that are used for irrigation (Section 5.1.1.2; Appendix F, Figures F-25 and F-26). Internal doses result from the inhalation of airborne effluents and the ingestion of food and water that contain radionuclides. DA-17

4.1.2.1 Atmospheric releases of radioactivity

Radioactive materials would be released to the atmosphere during L-Reactor operation from three release points: (1) from the 61-meter stack, which would discharge most of the gaseous effluents generated in reactor-building operation, (2) at ground level from evaporation of water from the fuel and target disassembly basin, and (3) at ground level from evaporation of water from the L-Area seepage basin. The releases from the stack would consist of radionuclide gases that enter the reactor ventilation system from the evaporation of process water, from the pressurized reactor blanket gas system, and from the air space between the reactor and the thermal shield.

Tritium releases would increase as the tritium content of reactor process water builds up to equilibrium. Table 4-8 lists the expected first- and tenth-year (equilibrium) atmospheric releases from normal L-Reactor operation (Du Pont, 1982b). The values are based on annual releases from P-, K-, and C-Reactor operations for 1978, 1979, and 1980; however, the values for tritium

Table 4-8. Expected annual atmospheric releases from L-Reactor operation[a] (curies per year)

Radionuclide	1st-year operation	10th-year operation
H-3[b]	5,490	54,900
C-14	12	12
Ar-41	19,500	19,500
Kr-85m	600	600
Kr-87	540	540
Kr-88	790	790
I-131	0.00414	0.00414
Xe-133	1,700	1,700
Xe-135	1,400	1,400
Unidentified beta-gamma[c]	0.0002	0.0002
Unidentified alpha[d]	0.000001	0.000001

[a]The expected annual average concentrations at the SRP site boundary would be well within the DOE concentration guides for uncontrolled areas (DOE, 1981b).

[b]Includes evaporative losses at ground level from the disassembly basin and the seepage basin.

[c]Assumed to be strontium-90.

[d]Assumed to be plutonium-239.

evaporation from the disassembly basin and for tritium from the seepage basin have been adjusted for more frequent target discharges expected at L-Reactor.

4.1.2.2 Wastewater discharges of radioactivity

During normal operations, radioactive materials would be discharged in liquid effluents from L-Reactor to Steel Creek as a result of small process-water leaks into the cooling water in the reactor heat exchangers, and by releases into the process sewer. Liquids (as much as 1890 cubic meters) would also be discharged about twice a year from the disassembly basin to the L-Reactor seepage basin (Figure 3-10). This purge of water would be necessary to keep the tritium concentration in the disassembly basin water below the level that ensures safe working conditions. The water in the disassembly basin would become contaminated when fuel and target assemblies are discharged from the reactor; some tritium and other radionuclides would be carried over in the process water adhering to the assemblies, and some as tritiated heavy water (DTO) contained as water of hydration in aluminum oxide on the assemblies. The disassembly basin water would be filtered, deionized, and monitored before it is discharged. The amount of tritium discharged in liquid effluents from L-Reactor would gradually TC increase with time as the tritium content of process water increases from neutron activation. After about 10 years of operation, the tritium content of process water would reach equilibrium (i.e., amount of new tritium produced equals amount lost through radioactive decay, leakage, and carryover and discharge operations) and remain relatively constant with continued reactor operation.

The migration of the discharged liquid in a shallow aquifer from the seepage basin to the outcrop along Steel Creek would allow the tritium to partially decay before being discharged to the creek. Only local and minor changes in watertable elevations are expected. The green clay and important confining clays in underlying formations would prevent releases to the seepage basin from impacting the upward head differential between the Tuscaloosa and Congaree Formations. It would also be an important barrier to the migration of contaminants from the seepage basin to lower hydrostratigraphic units. In the Separations Areas, the green clay (about 2 meters thick) supports a head difference of about 24 meters between the McBean and Congaree Formations. Based on water samples obtained for tritium analysis from the Congaree near the H-Area seepage basin
AW-1, DA-8 DA-18 [well 35-D (Figure F-34)], the green clay has effectively protected the Congaree ground water from contamination that enters the shallow ground-water system from the H-Area seepage basins (Marine, 1965). Water samples obtained in February 1984 from Well 35-D confirm the absence of tritium contamination in Congaree ground water. In the L-Area, the green clay is about 7 meters thick. Along the strike at the Par Pond pumphouse well (Figure F-13), the green clay also supports a large head difference. The water pumped from the Congaree Formation at the Par Pond pumphouse shows no evidence of tritium contamination, even though the tritium concentration in this lake was measured at 27,000 picocuries per liter. Water pumped from the Congaree by the pumphouse well exhibited tritium concentrations of 170 picocuries per liter or less, in comparison to concentrations of 260 ± 60 picocuries per liter in offsite well water (Ashley and Zeigler, 1981).

These discharges to a seepage basin would cause contamination of the uppermost layer of the water-table aquifer (Barnwell Formation). Subsurface contaminant migration is controlled by the rate and direction of ground-water flow, the absorptive capabilities of the sediments, and hydrodynamic dispersion. The sediments of the Savannah River Plant exhibit greater horizontal than vertical hydraulic conductivities, enhancing lateral movement (Root, 1983). Analyses indicate that the filtered and deionized disassembly-basin wastewater, after its discharge to the L-Reactor seepage basin, would seep into the shallow ground water and flow laterally to seepline springs along Steel Creek. The upward head differential between the Tuscaloosa and Congaree Formations at L-Area is presently about 3.7 meters (Figure 3-9; Section 3.4.2.1), except near the production wells, where the differential becomes 0.9 meter downward at 0.3 meter from
AW-1, DA-8 the centers of the cones of depression; current projections call for the continued presence of an upward differential for 10 or more years after L-Reactor operation resumes. This head differential and the clay layers beneath L-Area would tend to protect the Tuscaloosa Aquifer (see Section 4.1.1.3). The SRP has discharged contaminated wastewater to seepage basins in the central part of the Plant site since the mid-1950s. To date, no contamination of the Tuscaloosa Aquifer has occurred in this area (Ashley and Zeigler, 1981; Marine, 1965). Contaminants that might reach the Congaree or Tuscaloosa would be discharged to the Savannah River in about 76 or 250 years, respectively, as noted in Sections 4.1.1.3 and F.2.3.2, and in Du Pont (1983h).

Amounts of radioactive materials that reach the outcrop area on Steel Creek were calculated as a function of time, considering ground-water travel time from the seepage basin area to Steel Creek (4.4 years), radionuclide retardation by ion exchange, and radioactive decay (Du Pont, 1982b; also see Appendix B). However, based on a travel path of 490 meters, a gradient of 1.88 percent, and a ground-water velocity of 14.5 meters per year per percent gradient, a more realistic travel-time estimate is 18 years (Root, 1983; also see Table F-1).

Ashley, Zeigler, and Culp (1982) also considered the radioactive material released to the seepage basin during previous L-Reactor operations. Isotopes that are highly mobile (e.g., tritium, rubidium-106, and promethium-147) will already have left the area (in accordance with the ground-water travel time of 4.4 years and the fact that the previous radioactive releases to the seepage stopped in 1969). Other discharged isotopes (e.g., cobalt-60, strontium-90, and cesium-137), which are almost immobile, will result in negligible doses because they decay almost completely before they exit at the outcrop. EN-44

Table 4-9 shows expected annual liquid releases from L-Reactor operation for the first year and after the tenth year of operation (Du Pont, 1982b). The direct releases to Steel Creek and to the seepage basin are based on average annual releases from P-, K-, and C-Reactors during 1978, 1979, and 1980, but have been adjusted upward for the more frequent assembly discharges expected from L-Reactor operation. As noted in the table, 30 percent of the tritium discharged to the seepage basin is expected to be released to the atmosphere by evaporation. The expected average annual concentrations of radionuclides at the Steel Creek mouth are calculated to be well within the DOE concentration guides for uncontrolled areas (DOE, 1981b).

4.1.2.3 Dose commitments from releases from L-Reactor operation

Maximum individual dose from atmospheric releases. The individual who would receive the highest dose from atmospheric releases from L-Reactor was assumed to reside continuously at the SRP boundary about 12 kilometers from the reactor. The selection of the location of maximum potential dose was based on considerations of distance to the plant boundary, releases to the atmosphere, and meteorological dispersion characteristics.

The maximum total-body dose to an individual (a child) was calculated to range from 0.062 to 0.29 millirem in the first and tenth year, respectively (Table 4-10). These doses are only 0.067 and 0.31 percent, respectively, of the average dose of 93 millirem (Du Pont, 1982b) received by an individual living near the SRP site from natural radiation. More detailed dose data by age groups, organs, and exposure pathways are given in Appendix B.

Population dose from atmospheric releases. The total-body dose to the population of 852,000 (projected for year 2000) who would be living within 80 kilometers of the Savannah River Plant was calculated to range from 3.0 to 13.5 person-rem in the first and tenth year, respectively. More detailed dose data by age groups, organs, and exposure pathways are given in Appendix B.

Table 4-10. Annual total-body dose to maximally exposed individual from atmospheric releases from L-Reactor (millirem per year)

Age group	1st year	10th year
Adult	0.052	0.21
Teen	0.054	0.23
Child	0.062	0.29
Infant	0.051	0.16

Maximum individual dose from liquid releases. The individual who would receive the highest dose from liquid effluents from L-Reactor operation is assumed to live near the Savannah River, downstream from the Savannah River Plant. This individual is assumed to use river water regularly for drinking, to consume fish from the river, and to receive external exposures from shoreline activities, swimming, and boating. This individual is also assumed to drink more water and eat more fish than an average person.

Total-body doses to the various age groups for the maximally exposed individual are shown in Table 4-11. Detailed dose tables by age groups, organs, and exposure pathways are presented in Appendix B. Generally, children would receive the highest dose, ranging from 0.0094 millirem in the first year to 0.11 millirem in the tenth year. More than 75 percent of these doses would be from drinking water; most of the remainder would be from fish consumption. The highest calculated organ dose would be about 0.26 millirem to the child's bone in both the first and tenth year of L-Reactor operation.

Table 4-11. Annual total-body dose to maximally exposed individual from liquid releases from L-Reactor (millirem per year)

Age group	1st year	10th year
Adult	0.0072	0.087
Teen	0.0056	0.062
Child	0.0094	0.11
Infant	0.0062	0.11

Population dose from liquid releases. Savannah River water is not used for drinking within 80 kilometers of Savannah River Plant; therefore the dose to the population in this area would come from eating fish and shellfish, from shoreline activities, and from swimming and boating.

The total-body dose to the population of 852,000 estimated to be living within 80 kilometers of the Savannah River Plant in the year 2000 was calculated to range from 0.0088 to 0.018 person-rem in the first and tenth year, respectively (Table 4-12). About 90 percent of this dose would be from the consumption of fish.

DA-20 Table 4-12. Population total-body doses (100-year dose equivalents) from liquid releases from L-Reactor operation (person-rem per year)

Population group	1st year	10th year
80-km radius	0.0088	0.018
Beaufort-Jasper	0.29	5.0
Port Wentworth	0.46	8.2
Total	0.76	13.2

The Beaufort-Jasper and Port Wentworth population groups use the Savannah River as a source of potable water. While these groups are beyond the 80-kilometer radius of the Savannah River Plant (about 100 river miles downstream), the drinking-water doses have been calculated. The total-body dose delivered to these populations (about 317,000 people are expected to consume water from the Beaufort-Jackson and Port Wentworth water treatment plants by the year 2000) from drinking water was calculated to range from 0.75 to 13 person-rem in the first and tenth year of operation, respectively (Table 4-12). These doses would be about 0.0025 and 0.044 percent, respectively, of the exposure of about 29,500
TC person-rem to these populations received from natural radiation. Approximately 65 percent of the drinking-water dose would be from tritium in the first year of operation, increasing to greater than 95 percent in the tenth year. More detailed dose data by age groups, by organs, and by exposure pathways are given in Appendix B.

4.1.2.4 Cesium-137 and cobalt-60 redistribution dose commitment

As shown by Table 4-9, resumption of L-Reactor operation would add only small amounts of radionuclides to Steel Creek. However, the reactivation would transport a portion of the cesium-137 and cobalt-60 inventories that remain in the Steel Creek channel and floodplain.

The amount of cesium-137 and cobalt-60 transported from Steel Creek to the Savannah River and to the offsite Creek Plantation Swamp as the result of L-Reactor operation with the direct discharge of cooling water to Steel Creek (reference case) was calculated using empirical models based on monitoring in 1976 and 1982 of sediment and cesium-137/cobalt-60 transport in Steel Creek and on the historic flooding record for the swamp (Du Pont, 1982a, 1983a; Langley and Marter, 1973; Appendix D).

The total (both suspended solid and dissolved fraction) amount of radiocesium estimated to be remobilized and transported from Steel Creek during the first year of resumed L-Reactor operation would be 4.4 ± 2.2 curies. In the second year, it is anticipated that this value would be reduced to 2.3 ± 1.8 curies. Thereafter, a 20-percent reduction in transport per year is assumed. Thus, after 10 years of resumed operation, approximately 14.4 curies of cesium-137 would have been transported to the Savannah River-swamp system (Du Pont, 1983a).

The 2.1-curie decrease from the first to the second year is based on the assumption that the cooling-water effluent would no longer desorb radiocesium from the creekbed and floodplain sediments in Steel Creek and that no more radiocesium would be contributed from vegetation. Based on recent studies (Du Pont, 1983a), the sediment-water transport estimate presented here is substantially less than initially estimated (Du Pont, 1982a); however, the original estimates of transport resulting from hot water desorption (1.7 ± 0.2 curies) and the loss of vegetation containing 0.4 ± 0.2 curie remain unchanged (see Section D.4).

The total amount of radiocobalt to be remobilized and transported from Steel Creek during the first year of resumed L-Reactor operation is conservatively estimated to be 0.25 ± 0.13 curie. This total would consist of a 0.16-curie-per-year fraction associated with sediment-water transport and a 0.09-curie-per-year fraction associated with desorptive transport. During the second year, as much as 0.14 ± 0.10 curie would be transported in association with the suspended sediments (0.16 curie per year x 0.876 decay factor = 0.14 curie per year; Hayes and Watts, 1983). Approximately 0.6 curie of cobalt-60 would be transported to the Savannah River-swamp system during the first 10 years of resumed L-Reactor operation (Du Pont, 1983a).

Tables 4-13 and 4-14 list the amounts of cesium-137 and cobalt-60, respectively, that would be transported and concentrations in water for the first, second, and tenth years after resumption of L-Reactor operation. Maximum concentrations of cesium-137 and cobalt-60 occurring 1.5 river miles below Steel Creek mouth (the point of complete mixing of Steel Creek and river water) is predicted to be 1/425 and 1/3300, respectively, of the Environmental Protection Agency (EPA) drinking-water standard. Concentrations in finished water from the Beaufort-Jasper and Cherokee Hill water treatment plants are predicted to be small fractions (at most 1/2200 and 1/4160 for cesium-137 and cobalt-60, respectively) of these drinking-water standards (Du Pont, 1983a).

The methodology used to calculate dose commitments for remobilized radiocesium and cobalt-60 is discussed in Appendix B. The dose calculations were made with the assumption that all cesium-137 and cobalt-60 released from Steel Creek would reach the Savannah River and complete mixing in the river would occur within 2.4 kilometers of the mouth of Steel Creek at an annual average river flow rate of 295 cubic meters per second. The dose associated with the first year of L-Reactor operation was analyzed because releases would be highest in that year (4.4 curies of cesium-137 and 0.25 curie of cobalt-60) and would decrease continuously in subsequent years.

Maximum individual dose. The dose to the maximally exposed individual from redistribution of cesium-137 and cobalt-60 in the first year is shown in Table 4-15 by age groups. An adult would receive the maximum total-body dose of 3.5 millirem. Greater than 99 percent of this dose is from cesium-137. Fish consumption (34 kilograms per year) would account for 99 percent of the dose, and drinking water (730 liters per year) for 0.7 percent. Shoreline activities, swimming, and boating would account for the remainder of the dose. The maximum dose to an organ was calculated to be 5.3 millirem to the liver of a teenager and an adult. The total-body dose to an adult would decrease to 0.31 millirem in the tenth year.

Population dose. The total-body dose to the population within 80 kilometers of the Savannah River Plant from freshwater fish and saltwater shellfish consumption and from recreational activities on the river was calculated to be 9.0 person-rem in the first year (Table 4-16). About 99 percent of this dose would be from consumption of river fish and is almost entirely from cesium-137. Total-body dose to water consumers in Port Wentworth and Beaufort-Jasper was calculated to be 0.80 person-rem in the first year. About 95 percent of this dose would be accounted for by cesium-137. The dose calculations for these water consumers take into account the removal of a large fraction of the cesium-137 during the water-treatment process (Du Pont, 1983a). In the tenth year, the 80-kilometer-radius population dose would decrease to 0.80 person-rem and the combined Beaufort-Jasper and Port Wentworth water consumer dose would decrease to 0.067 person-rem. Additional tables providing detailed cesium-137 and cobalt-60 dose results by age groups, organs, and exposure pathways are given in Appendix B.

4.1.2.5 Summary of offsite dose commitments from L-Reactor operation

Table 4-17 summarizes the maximum individual and population dose commitments resulting from the resumption of L-Reactor operation. The numbers listed as totals for individual and population doses are conservative maximums; to receive these doses, the "composite" individual (or population) would have to occupy several locations simultaneously. In addition, the dose for radiocesium and cobalt-60 transport calculated for the first year would decrease continuously in subsequent years.

The composite maximum individual dose of 3.6 millirem would occur in the first year of L-Reactor operation and is about 26 times less than the average dose of 93 millirem (Du Pont, 1982a) received by an individual living near the SRP site from natural radiation. The composite dose in the tenth year would be 0.61 millirem. These doses are on the order of 1 percent or less of the DOE radiation protection guides (DOE Order 5480.1A, Chapter 11). The maximum population dose of 27.6 person-rem in the tenth year of L-Reactor operation would be less than 0.025 percent of the exposure of about 109,000 person-rem to the population living within 80 kilometers of the Savannah River Plant and the Beaufort-Jasper and Port Wentworth drinking-water population from natural radiation sources.

Table 4-17. Summary of total-body dose commitments from the operation of L-Reactor

Source of exposure	1st-year dose		10th-year dose	
MAXIMUM INDIVIDUAL ADULT DOSE (MILLIREM PER YEAR)				
Atmospheric releases	0.052		0.21	
Liquid releases	0.0072		0.087	
Radiocesium and cobalt transport	3.5		0.31	
Total	3.6		0.61	
Source of exposure	**Dose within 80 kilometers of SRP**		**Port Wentworth and Beaufort-Jasper dose**	
	1st year	**10th year**	**1st year**	**10th year**
REGIONAL POPULATION DOSE (PERSON-REM PER YEAR)				
Atmospheric releases	3.0	13.5	--	--
Liquid releases	0.0088	0.018	0.75	13.2
Radiocesium and cobalt transport	9.0	0.80	0.80	0.067
Total	12.0	14.3	1.6	13.3

4.1.2.6 Health effects from L-Reactor operation

Radiation-induced health effects that could occur as a result of the resumption of L-Reactor operation (including atmospheric and liquid radioactive releases and radiocesium remobilization) were calculated using BEIR III risk estimators (Appendix B). The risk estimators used were 120 cancers and 257 genetic effects per 1,000,000 person-rem exposure. Multiplying the regional population doses (from Table 4-17) by these risk estimators projects the following effects: a maximum of 0.001 excess cancer fatality in the population within 80 kilometers of the Savannah River Plant from first-year L-Reactor operations, 0.002 excess cancer fatality from tenth-year operations, 0.003 genetic disorders from the first year of operation and 0.004 from the tenth year. Health effects that could occur in the downstream Savannah River water-consuming populations of Port Wentworth and Beaufort-Jasper include a maximum of 0.0004 excess cancer fatality from first-year operations, and 0.002 from tenth-year operations. The maximum risk of genetic disorders to these populations would be 0.0004 from first-year operations, and 0.003 from tenth-year operations.